12/22/98 JC588 U.S. PTO

A

PATENT

Docket No. *D-350*

Commissioner of Patents and Trademarks
Washington, D.C. 20231

JC542 U.S. PTO 09/220184 12/22/98

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): Robert B. Dybdal

For (title): ORTHOGONAL POLARIZATION AND FREQUENCY SELECTABLE WAVEGUIDE

1. Type of Application

This new application is an **ORIGINAL** application.

2. Benefit of Prior U.S. Application(s) (35 USC 120) - None

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this New Application Transmittal and the documents referred to as enclosed therein are being deposited with the United States Postal Service on this date December 22, 1998 *in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number* EE890426003US *addressed to the: Commissioner of Patents and Trademarks, Washington, D.C. 20231*

Carole A. Mulchinski
(Type or print name of person mailing paper)

Carole A. Mulchinski
(Signature of person mailing paper)

3. Papers Enclosed Which Are Required for Filing Date Under 37 CFR 1.53(b) (Regular) or 37 CFR 1.153 (Design) Application

25 Pages of specification
9 Pages of claims
1 Pages of Abstract
5 Sheets of drawing

/__/ informal

/X/ in triplicate

4. Additional papers enclosed

/__/ Preliminary Amendment

/__/ Information Disclosure Statement

/__/ Form PTO-1449

/X/ Small Entity Statement

5. Declaration or oath executed by INVENTOR(S)

/X/ Enclosed

6. Inventorship Statement

The inventorship for all the claims in this application is THE SAME.

7. Language: ENGLISH

8. Assignment

/X/ An assignment of the invention to The Aerospace Corporation P. O. Box 92957 (M1/040), Los Angeles, CA 90009-2957

/X/ is attached

/__/ will follow

9. ***Certified Copy***

Certified copy(ies) of application(s) X are not applicable ____ are attached ____ will follow.

10. *Fee Calculation*

/X/ **Regular application**

CLAIMS AS FILED

Number Filed				Number Extra		Rate	Basic Fee $790.00
Total Claims	-	14	-20=	0	X	$ 22.00	
Independent Claims	-	3	-3=	1	X	$ 41.00	00.00
Multiple dependent claim(s), if any						$270.00	

/ / **Amendment cancelling extra claims enclosed**

/ / **Amendment deleting multiple dependencies enclosed**

/ / **Fee for extra claims is not being paid at this time**

Filing Fee Calculation **$790.00**

11. *Small Entity Statement(s)*

/X/ Verified Statement(s) that this is a filing by a small entity under 37 CFR 1.9 and 1.27 is(are) attached.

$395.00

12. *Fee Payment Being Made At This Time*

/ / No filing fee is to be paid at this time. (This and the surcharge required by 37 CFR 1.16(e) can be paid subsequently.)

/X/ Enclosed

/X/ Basic filing fee $ 395.00

/X/ Recording assignment ($40.00; 37 CFR 1.21(h)(1)) $ 40.00

Total fees enclosed **$ 435.00**

13. ***Method of Payment of Fees***

/X/ charge Account No. 01-0428 in the amount of $ 435.00.
A duplicate of this transmittal is attached.

14. ***Authorization to Charge Additional Fees***

/X/ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 01-0428.

/X/ 37 CFR 1.16 (filing fees)

/X/ 37 CFR 1.16 (presentation of extra claims)

/X/ 37 CFR 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

/X/ 37 CFR 1.17 (application processing fees)

/X/ 37 CFR 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 CFR 1.311(b).

15. ***Instructions As To Overpayment***

/X/ credit Account No. 01-0428.

Reg. No.: 32,096

Signature of Attorney

Tel. No. (310) 336-6708

Derrick Michael Reid
Type or print name of attorney

THE AEROSPACE CORPORATION
P.O. Box 92957 (M1/040)
Los Angeles, CA 90009-2957

/X/ This transmittal ends with this page.

Attorney's Docket No. D-350

Applicant or Patentee: Robert B. Dybdal

Serial or Patent No.: ______

Filed or Issued: ______

For: Orthogonal Polarization and Frequency Selectable Waveguide

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(d))--NONPROFIT ORGANIZATION

I hereby declare that I am an official empowered to act on behalf of the nonprofit organization identified below:

NAME OF ORGANIZATION The Aerospace Corporation

ADDRESS OF ORGANIZATION P. O. Box 92957 (M1/040)

Los Angeles, CA 90009-2957

TYPE OF ORGANIZATION

/X/ TAX EXEMPT UNDER INTERNAL REVENUE SERVICE CODE (26 USC 501 (a) and 501 (c) (3)

I hereby declare that the nonprofit organization identified above qualifies as a nonprofit organization as defined in 37 CFR 1.9(e) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code with regard to the invention entitled Dual Polarized Selectable Waveguide

by inventor(s) Robert B. Dybdal

described in

/X/ the specification filed herewith

/ / application serial No. ______, filed ______.

I hereby declare that rights under contract or law have been conveyed to and remain with the nonprofit organization with regard to the above identified invention.

If the rights held by the nonprofit organization are not exclusive, each individual, concern or organization having rights to the invention is listed and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

I acknowledge the duty to file, in this application or patent, notification of any charge in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Robert Donald Matthews

TITLE IN ORGANIZATION Assistant General Counsel

ADDRESS OF PERSON SIGNING The Aerospace Corporation

P. O. Box 92957 (M1/040), Los Angeles, CA 90009-2957

SIGNATURE Robert Donald Matthews DATE 12/17/98

Attorney's Docket No. D-350

Applicant or Patentee: Robert B. Dybdal

Serial or Patent No.: ______

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Robert Donald Matthews

TITLE IN ORGANIZATION Assistant General Counsel

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For: Orthogonal Polarization and Frequency Selectable Waveguide

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described in

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/ / application serial No. __________, filed __________.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Robert Donald Matthews

TITLE IN ORGANIZATION Assistant General Counsel

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P. O. Box 92957 (M1/040), Los Angeles, CA 90009-2957

SIGNATURE Robert Donald Matthews DATE 12/17/98

PATENT APPLICATION

Docket No.: D350

Inventor(s): Robert B. Dybdal

Title: Orthogonal Polarization and Frequency Selectable Waveguide

SPECIFICATION

Statement of Government Interest

The invention was made with Government support under contract No. F04701-93-C-0094 by the Department of the Air Force. The Government has certain rights in the invention.

Field of the Invention

The invention relates to the field of antenna systems used in satellite communications where orthogonal polarizations are employed to increase system capacity.

Background of the Invention

The demands for satellite communication capacity have resulted in the implementation of several different techniques. One technique is to extend satellite capacity using orthogonal polarization states to send two independent signals to the same coverage region thereby doubling the information that can be delivered to that region. This technique is referred to as polarization reuse. The success of this technique depends in part on the ability to maintain the separation of the two signals to avoid mutual interference that degrades communication performance. The required signal separation in turn imposes requirements on the polarization purity of the signals.

Polarization reuse is very commonly used on commercial satellites operating at the C band (4-6 GHz) and Ku band (11-14 GHz) frequencies. The required separation between signals used in these systems depends on the power differences in the signal levels and the susceptibility of the reception to co-channel interference. A typical requirement for the polarization purity needed for signal separation is to limit the reception of the undesired signal to a level that is 27 dB lower, that is, 1/500 of the power, than the desired signal component. The degree of polarization purity required to satisfy this requirement is significantly more stringent than the polarization purity required to insure minimal signal loss caused by polarization mismatch.

Different satellite systems, however, are not consistent in the polarization states used. Some systems use orthogonal linear polarization states while other systems use orthogonal circular polarization states. Within a given satellite system, antenna systems for a single polarization state have been developed. However, if antenna systems are developed for use with several different satellite systems, the antenna system requires the capability to select the polarization state depending on the satellite system being used. Clearly, antenna systems capable of operating with different satellite systems afford advantages in flexibility and potential cost effectiveness. However, such antenna designs have to be fully compatible with the requirements for each satellite system. In view of the various polarization signaling methods, antenna systems designed for inter-program compatibility must be capable of processing dual polarization signals with either linear or circular polarization states and must meet system requirements for polarization purity.

The design requirements to achieve the requisite polarization purity must address the antenna, its feed system, and the ports for each polarization. These design requirements must be maintained over the entire bandwidth spanned by the satellite systems. The antenna, for example, must be designed with a high degree of symmetry so that cross polarized components are not generated that would degrade polarization purity. Similarly, the feed system must be designed to produce rotationally symmetric illumination of the antenna system and attention must be paid to the excitation of higher order modes

that produce cross polarized components that degrade polarization purity. The terminals of the feed system must be constructed with precision to avoid polarization coupling, and any combining circuitry used to transform polarization states must satisfy stringent matching requirements to avoid the generation of cross polarized components that degrade polarization purity. The satisfaction of the overall system requirements for polarization purity is limited by the aggregate of the imperfections in the antenna, feed system, terminals and transforming circuitry.

One fundamental limitation in the development of designs that permit selection of the polarization state results from the inherent imperfections when hybrid combining circuitry is used to transform polarization states. The conventional approach to this problem is to combine one of the polarization states with hybrid circuitry to obtain the other polarization state. The limitation of this approach lies with the inherent imperfections of the hybrid. Quadrature hybrids needed to convert the linearly polarized state to the circular polarized state can maintain a ninety degree phase shift but the amplitude response is unequal over the bandwidth. This amplitude imbalance results in coupling between the two polarization states resulting in co-channel interference. When linearly polarized components are transformed to circularly polarized components, for example, the circular components are obtained from the addition of equal levels of each linearly polarized component with a ninety degree phase shift between the components. Such combining is typically implemented using a quadrature hybrid. Practical hybrids provide the

appropriate ninety degree phase shift but exhibit the problem of an imbalance when combining the amplitudes that then varies over the required bandwidth. This amplitude combining imbalance is a limiting factor in achieving the polarization isolation needed to maintain signal separation. A similar limitation exists with one hundred and eighty degree hybrids used to combine circularly polarized components to obtain linearly polarized components. One problem with one hundred and eighty degree hybrids is the resulting phase imbalance. A second problem is the insertion loss inherent when using combining circuitry results. Such insertion loss degrades system sensitivity. The insertion loss reduces transmitted power delivered to the antenna and also limits the power handling because the thermal energy resulting from the insertion loss must be dissipated. The insertion loss in receiving antennas not only reduces the received signal strength but also increases the total system temperature, a factor that is extremely important when modern low noise receivers are used.

A means of switching is also required to select between the polarization states. Three distinct switch technologies exist. Diode switch devices can switch very rapidly but are relatively lossy and limited in their power handling capability. Ferrite switching technology has somewhat less loss, slower switching time, and greater power handling capability and very low loss, but with disadvantageous slow switching times. The low loss and power handling capabilities are desired in this polarization reuse applications and rapid switching may not present a problem.

Thus, waveguide switch technology is preferred in this polarization reuse application having low loss and high power handling capabilities, but with slow switching times. Conventional waveguide switch has a single dominant waveguide mode. A dominant waveguide mode may be TE01 or TE10 for square polarized signals and orthogonally disposed TE11 for circular polarized signals. Tapers and frequency selective surfaces have long been used for frequency isolation. The most familiar waveguide switch uses rotating waveguide bends to route the signals between four ports. The conventional waveguide switch has two selectable position settings for aligning two curved waveguide section bends symmetrical about a rotating axis. The curved selectable waveguide section does not use reflecting surfaces, but rather circular or rectangular cross section waveguide sections. This dual position arrangement is analogous to a double-pole double throw switch. This configuration is commonly referred to as a baseball switch, because the waveguide bends resemble the stitching on a baseball. However, this switch technology is not capable of switching orthogonally polarized signals because the bends inherently result in coupling between the linear and circular polarized signals. These and other disadvantages are solved or reduced using this invention.

Summary of the Invention

An object of the invention is the capability to receive and/or transmit dual orthogonally polarized signals with selection between linear and circular states.

Another object of the invention is to achieve a high degree of polarization purity over a wide bandwidth to avoid co-channel interference of one signal to another.

Yet another object of the invention is to achieve a low loss design to increase system efficiency in antenna systems.

A further object of the present invention is to provide the means of transmitting and/or receiving two orthogonally polarized antenna signals with a high degree of polarization purity and with low loss and the capability to select either linearly or circularly polarized polarization states.

Yet a further object of the present invention is to provide the capability for a dual polarized, selectable polarization state waveguide capable of operation for multiple frequency bands.

The present invention is directed towards a waveguide switch having a plurality of switch positions for communicating a signal between at least one input port and a respective plurality of output ports through a respective plurality of dissimilar

waveguide sections. In the preferred form, the waveguide switch has two output ports respectively connected to the input port through a straight waveguide section and a bent waveguide section. The waveguide switch is preferably used to receive and/or transmit dual polarized signals through an antenna feed input port between a linear output port using the bent waveguide section coupled to a linear polarization state sensitive probe and a circular output port coupled to a circular polarized probe using the straight waveguide section providing the capability to select either linearly or circularly polarized polarization state signal transmitted through the antenna feed port. This present invention provides a high level of polarization purity needed to separate two independent signals by polarization. The present invention is directed to selectable waveguides having selectable waveguide sections to perform the polarization state selection, and the loss incurred by these sections is much less than the losses in hybrid combining circuitry used in the conventional polarization state transformations. The waveguide sections can be sized, cascaded and coupled to frequency sensitive tapers and couplers for both polarization state selection and frequency selection of signals in applications where multiple frequency or multiple polarization state operation is required, for example, in simultaneous C band and Ku band operation.

The preferred selectable waveguide has two positions for respectively selecting one of two waveguide sections within the selectable waveguide. The selectable waveguide is capable of propagating the two independent orthogonal channels. A waveguide

is connected to an antenna feed capable of propagating two independent orthogonally polarized communication channels. A selector switch, knob, or other mechanical means on the waveguide is used to select one of the two waveguide sections to thereby select one of the two independent orthogonally polarized communication channels. Output ports of the selectable waveguide are used for separating the respective polarization states of the channels using respective polarization sensitive probes. The waveguide switch is thus used to route the transmitting or receive channel signals into either the circular polarized output port realized by an orthomode transducer capable of high polarization purity over wide bandwidths or to the linear polarized output port realized by an orthogonal linear polarized probe in the waveguide capable of high polarization purity over wide bandwidths.

Preferably, the selector switch is used to transfer either linear or circular polarization signal components to respective ports. Like the conventional waveguide switch, the selection is preferably accomplished by mechanical rotation. Unlike conventional switches, however, the improved selectable waveguide has dissimilar waveguide sections that can respectively operate in two dominant modes. One switch setting consists of a straight waveguide section so that higher order modes and mode coupling does not occur. The second switch setting changes the direction of propagation by ninety degrees using a waveguide miter bend to avoid higher order mode generation. The axis of rotation is offset to permit the rotation of the switch and the port

alignment. The improved selectable waveguide switch of the present invention is effectively a single-pole double-throw waveguide switch using three ports.

These selectable waveguide switches can be frequency sized and cascaded for multiple frequency applications. Such cascading can be readily performed when the switch has the straight waveguide section. When the switch is placed in the position of bent section containing a miter bend, the conducting miter is replaced by a frequency selective surface to allow passage of the higher frequency signals to subsequent selector waveguide switches. Frequency sensitive couplers and tapers can be coupled to the switches to various operational configurations for selecting the signal of desired frequency and polarization. In addition to the ability to maintain polarization purity, the waveguide sections of the selector switch have little loss in comparison to hybrid network losses in the conventional approach. These and other advantages will become more apparent from the following detailed description of the preferred embodiment.

Brief Description of the Drawings

Figure 1 is a drawing of a selectable waveguide switch shown in the straight position.

Figure 2 is a drawing of the selectable waveguide switch shown in the bent position.

Figure 3a is a drawing of a modified selectable waveguide having a modified bent waveguide section.

Figure 3b is a drawing of the modified selectable waveguide in the straight position with an attached coupler for multiple frequency operation.

Figure 4 is a drawing illustrating a cascade arrangement of selectable waveguides for multiple frequency operation.

Detailed Description of the Preferred Embodiment

An embodiment of the invention is described with reference to the figures using reference designations as shown in the figures. Referring to both Figures 1 and 2, a selectable waveguide can be positioned into one of two positions, a straight waveguide position shown in Figure 1 and a bent waveguide position shown in Figure 2. An antenna feed port 10 communicates a feed signal 12 to and from an antenna feed 13. In the straight

position, the antenna feed port 10 communicates the feed signal 12 through a straight waveguide section 14 to a circular port 16 communicating a circular port signal 18. The waveguide sections 14 and 20 are physically sized to transmit and receive signals within desired frequencies bands. The circular port signal 16 may be either a linearly polarized signal or a circularly polarized signal or may comprise a plurality of differing polarized signals. The circular port 16 is coupled a circular port probe 19 for communicating the circular port signals 18 to and from the antenna feed port 10. The feed signal 12 is either a linear polarized signal or a circular polarized signal, or may be a composite signal having a plurality of differing polarized signals having respective polarized states. In the bent position, the selectable waveguide communicates the feed signal 12 through a bent waveguide section 20 to a linear port 22 communicating a linear port signal 24 that may be either a linearly polarized signal or a circular polarized signal and that may comprise a plurality of differing polarized signals. The linear port 22 is coupled to a linear port probe 25 for communicating the linear port signal 24 to and from the antenna feed port 10.

The bent waveguide section 20 has a reflecting surface 26 for reflecting the feed signal 12 and linear port signal 24 communicated through the bent waveguide section 20. The direction of the signal path through the bent waveguide section 20 is reflected by ninety degrees using the reflecting surface 26 in the path of the bent waveguide section 20 to communicate

linear polarized signals between the linear port 22 and the antenna feed port 10. The reflecting surface 26 is for reflecting signals 24 and 12 communicated through the bent waveguide section 26. This reflection is achieved by a miter bend to avoid mode conversion and coupling between the polarized component signals of the signals 24 and 12 that would reduce the separation between component signals.

It should be apparent that the bent waveguide section 20 could be a curved waveguide or other suitable waveguide section so long at it connects the feed port 10 to the port 22 when in a first position, and is therefore dissimilar to in shape to the straight waveguide section 20. Also, the straight waveguide section 20 could be a curved waveguide section or other suitable waveguide section so long at it connects the feed port 10 to the port 16 when in a second position, and is also therefore dissimilar in shape to the bent waveguide section 20. That is, the two waveguide sections 14 and 20 must be dissimilar in shape for connecting the feed port 10 to respective output ports 16 and 22. However, curved waveguide sections are limited to a single polarization state. Additionally, while the preferred form has only two sections 14 and 20, additional sections could be added, so that there is at least a plurality of the dissimilar waveguide with respective sections and output ports.

The port 10 is designated generally as an input port, and, the ports 22 and 16 are designated generally as output ports, but, ports 16 and 22 may transceive signals 24 and 18 to and from

the port 10 as the feed signal 12. The signal 12 is generally designated as an input signal having a plurality of component signals, such as signals 24 and 18, having differing orthogonal polarization states, such as linear or circular polarization states, left hand circular or right hand circular polarization states, and linear horizontal or linear vertical polarization states. The signal separation and isolation by desired polarization states are realized by polarization sensitive probes 19 and 25 and waveguide switch selection at the respective straight and bent switch positions.

To change positions from a bent waveguide position to and from a straight waveguide position, the selectable waveguide has a rotating selector knob 28 or other mechanical means for rotating a rotating element 30 supporting the bent waveguide section 20 and straight waveguide section 14 on a stationary housing 32. The selectable waveguide preferably uses the rotating element 30 in the stationary housing 32 to change positions for respectively communicating signals 18 or 24. As preferably designated, the selectable waveguide uses the bent waveguide 20 to communicate linearly polarized signals 24 and uses the straight waveguide 14 to preferably communicate circularly polarized signals 182. The bent waveguide section 20 and the straight waveguide section 14 can have either a square or circular cross section and sized for the frequencies of interest. The manually actuated rotating knob 28 is rotated to connect either the bent waveguide 20 or the straight waveguide 14 between the antenna feed port 10 and either of the linear port 22 or the

circular port 16, respectively. Hence, the bent waveguide section 20 preferably communicates a linearly polarized signal 24 as feed signal 12 between the linearly polarized port 22 and the antenna feed port 10, and, the straight waveguide section 14 preferably communicates circular polarized signals 12 as feed signal 12 between the circularly polarized port 16 and the antenna feed port 12. Hence, the rotating knob 28 only has two positions, the first position connecting the linear port 22 to the antenna feed port 10 for linearly polarized signal communication, and the second position connecting the circular port 16 to the antenna feed port 10 for circularly polarized signal communication.

The polarization sensitive probes 19 and 25 are preferably used to separate by polarization states the two orthogonal polarized signals 18 and 24. The linear port 22 may communicate two independent signals separated by orthogonal polarization states, such as, linear horizontal and linear vertical polarization states. Likewise, the circular port 22 may communicate two independent signals separated by orthogonal polarization states, such as, left hand and right hand circular polarization signals. Each of the probes 19 or 25 are preferably responsive to a predetermined polarization state and as such are used to isolate and separate two independent orthogonally polarized component signals.

By rotating the rotating element for waveguide section alignment, the probes 19 and 25 are thereby rotated into a

position for receiving or transmitting one of the plurality of differing polarized signals, thereby perfecting a polarization state selection. The waveguide cross sections 14 and 20 remains unaltered from the antenna feed port 10 to either of the linear port 22 and the circular port 16. The cross section areas of the waveguide sections 14 and 20 remain fixed within the selectable waveguide. Because the waveguide cross section remains unchanged, no mechanism exists for polarization modifications from antenna feed port 10 through the waveguide sections 14 and 20 to the ports 22 and 16. Consequently, the waveguide does not degrade polarization isolation. The waveguide cross sections 14 and 20 may be square and in this case the signals are propagated on TE01 and TE10 waveguide modes. The waveguide cross section can also be circular and the signals 18 and 24 are propagated on orthogonal TE11 waveguide modes. Hence, the waveguide cross section of the sections 14 and 20 is preferably preserved throughout the rotating member 30.

The waveguide section selection, and hence polarization state selection, by rotating the knob 28, may be by conventional mechanical means to route the feed signals 12 to one of port 22 and 16 to thereby place a respective polarization sensitive probe 19 or 25 in the path of feed signal 12. Like conventional waveguide baseball switches, the rotation can be manually performed or accomplished by using a motor drive that can be remotely controlled. However, the waveguide section selection knob 28 has the improved features of offering polarization state selection using dissimilar waveguide sections 14 and 20 and using

respective dissimilar polarization state sensitive probes 19 and 25. The rotating knob 28 is used to both select one waveguide section 14 or 20, and to simultaneously select the one of the two respective probes 19 and 25 to perfect polarization state selection. The first switch selection position selects the straight waveguide section 14 and probe 19 to connect the antenna feed port 10 to the circular port 16, and to select the polarization sensitive probe 19 communicating signal 24 of one polarization state. The second switch selection position is obtained by rotating the knob one hundred and eighty degrees to select the bent waveguide section 20 of the selectable waveguide to connect the antenna feed port 10 to the linear port 22, and to select the probe 24 communicating signal 18 having a differing polarization state. Hence, the knob 28 is in effect a polarization state selection knob 28 to select one of a plurality of orthogonally polarized signals without coupling energy between the signals that would otherwise degrade the signal separation.

Communication devices, such as probes 19 and 25, connected at the circular port 16 and the linear port 22, are designed to separate the component signals by their polarization states. A means for separating polarized signals 10 is to place probes in a waveguide section located ninety degrees apart in adjacent walls of the waveguides. Similarly, the ports 22 and 16 would separate polarized signals typically by an orthomode probe. These probes for separating signals by polarization are well known and capable of operation over wide bandwidths.

The losses in dual polarized signal communication through the selectable waveguide result from the losses within the waveguide sections 14 and 22 which losses are very small. The losses in the waveguide sections 14 and 20 are less than the insertion losses associated with conventional hybrid networks. Thus, signal reception and transmission for the present invention are more efficient. The waveguide sections 14 and 20 are preferably used to select one of the two orthogonally polarized signals by virtue of the polarization sensitivity of the probes 19 and 25, but can also be used to select signals 18 and 24 of differing frequencies.

Referring to Figures 3a, a modified selectable waveguide 39 may be used for both polarization state and frequency selection of the feed signal 12 communicated to the antenna feed 13. The modified selectable waveguide section 40 can be used in applications where multiple frequency operation is required. The waveguide 39 is initially sized to communicate signals within desired frequency bands. The modified selectable waveguide 39 includes a modified bent waveguide section 40 having an extended straight portion 42 and a frequency selective reflective surface 44. The extended portion 42 is aligned to the port 16 when the bent waveguide section 40 is aligned to port 22 when the modified selectable waveguide 39 is switched to the bent position. The frequency selective reflective surface 44 is used to reflect signals 24 of one frequency, such as low frequency signals, to the port 22, and to pass signals of another frequency, such as high frequency signals, to the port 16. The probes 19 and 25 can

then be used to select signals of differing polarization states, and by virtue of the frequency sensitive reflective surface 44, concurrently select signals of differing frequencies.

Referring to Figure 3b, the modified selectable waveguide 39 is attached to a coupler 46 having a left hand port 48 communicating left hand port signal 47 to a left hand probe 49, and, having a right hand port 50 communicating right hand port signals 51 to a right hand probe 53. As such, the probes 53 and 49 are used to isolate orthogonally polarized signals, such as right hand circular and left hand circular polarized signals. It should be apparent that the coupler 46 functions as a splitter providing two outputs, and that the coupler 46 and probes 49 and 53 could, as well, be attached to port 22 for respectively communicating horizontal linear and vertical linear orthogonally polarized signals 24. The coupler 46 has a taper port 52 for attenuating low frequency component signals and passing high frequency component signals 54 to the probe 19. Hence, the modified selectable waveguide 39 can be modified to include means that provide frequency selection while the probes 15 and 19 can be used to select desired polarization states to isolate signals of interest. It should now be equally apparent, that the selectable waveguide of Figures 1 and 2, and or the modified selectable waveguide 39 of Figures 3a and 3b, can be used in combination with various probes, couplers and tapers to isolate signal of desired polarization states and frequencies. Further still, the selectable waveguide of Figures 1 and 2, and or the modified selectable waveguide 39 of Figures 3a and 3b, can be

cascaded and used in combination with various probes, couplers and tapers to isolate many different signals of respective desired polarization states and frequencies.

Referring to Figure 4, two modified selectable waveguides, a front end waveguide 39a and a back end waveguide 39b, are cascaded for multiple frequency and multiple polarization state communication applications. Frequency selection and polarization state selection are enabled by the cascaded arrangement in combination with various probes, couplers and tapers. The two waveguides 39a and 39b are both shown in the straight position, but either or both may be rotated to the bent position, thereby providing a four position cascaded arrangement providing a straight-straight position, a straight-bent position, a bent-straight position and a bent-bent position.

In the straight position, the waveguide dimension is chosen to permit propagation of all system frequencies. The straight position is preferably used for communicating circularly polarized signals at the lower frequencies. All of the signals propagate unmodified through the straight waveguide sections 14ab. At the output circular port 16a of the modified selectable waveguide 39a, the coupler 46a is used to separate the lowest frequency signals into ports 48a and 50a. The port 48a can be used for left hand polarized signals, and the port 50a can be used for selecting right hand polarized signals in the lowest frequency band. The coupler 46a is transparent to the higher frequencies. The design of such couplers is well known and

commonly used. The waveguide taper 52a follows the coupler 46a so that the waveguide size is reduced permitting propagation of signals of all frequencies except the lowest frequency signals. The second modified selectable waveguide 39b has smaller dimensions and follows the taper port 52a. The selectable waveguide 39a is transparent to frequency bands above the lowest frequencies. The coupling of the lower frequency band to ports 22ab is enabled in the bent positions. The miter bends have frequency selection surfaces 44ab in place of a conducting surface 26 used by the single frequency selectable waveguide switch design. These frequency selective miter surfaces 44ab reflect the lowest frequency signals 24ab into the linearly polarized ports 22ab for connection to respective probes 25ab. The frequency selective miter surfaces 44ab are transparent to higher frequencies so that the higher frequency signals 54a can be communicated through the cascaded arrangement at the higher frequencies.

Each of the modified selectable waveguides 39ab, respectively includes ports 16ab, 22ab, 48ab and 50ab, tapers 52ab, straight waveguide sections 14ab, and bent waveguide sections 40ab. Waveguide 39a has the feed port 10a receiving the feed signal 12 and provides the output signal 54a that is fed into the feed port 10b of waveguide 39b to provide the output signal 54b to probe 19. Probes 25ab respectively communicating signals 24ab, probes 49ab respectively communicating signals 47ab, probes 53ab respectively communicating signals 51ab, and probe 19 communicating signal 54b, all of which can be used for

selecting signals of differing frequencies and polarization states.

The cascaded arrangement places the low frequency band modified selectable waveguide 39a closest to the antenna feed port 10a and the antenna feed 13, whereas the high frequency band modified selectable waveguide 39b may be used to communicate signals in a high frequency band. In the polarized selectable waveguide 39a closest to the antenna feed 13, a modification can be made to miter bend. In single frequency designs, the miter bend 44a consists of a conducting surface 26. In the multiple frequency design, the conducting miter surface 26 is replaced by a frequency selective surface 44a capable of reflecting the lowest frequency components and passing the higher frequency components. The coupler 46a passes only low frequency signals to ports 48a and 50b. The coupler 46b passes only high frequency signals to the ports 48b and 50b. Another frequency selective surface 44b can be used to prevent mode conversion and signal loss for the higher frequency components. The frequency selective surfaces 44a and 44b and taper ports 52a and 52 can be used for low, high, higher frequency band isolation.

In the straight-straight position, the arrangement passes low frequency signals 47a and 51a, passes high frequency signals 54a, 47b and 50b, and passes higher frequency signals 54b. In the bent-straight position, the arrangement passes low frequency signals 25a, passes high frequency signals 54a, 47b and 50b, and passes higher frequency signals 54b. In the straight-bent

position, the arrangement passes low frequency signals 47a and 51a, passes high frequency signals 54a, 25b, 47b and 51b, and passes higher frequency signals 54b. In the bent-bent position, the arrangement passes low frequency signals 25a, passes high frequency signals 54a and 25b, and passes higher frequency signals 47b, 50b, and 54b. Preferably, the port 22a communicates low frequency linearly polarized signals 24a to probe 25a, port 48a communicates low frequency left hand circularly polarized signals 47a to probe 49a, port 50a communicates low frequency right hand circularly polarized signals 51a to probe 53a, port 52a communicates high frequency signals to port 10b, port 22b communicates high frequency linearly polarized signals 24b to probe 25b, port 48b communicates high frequency left hand circularly polarized signals 47b to probe 49b, port 50b communicates high frequency right hand circularly polarized signals 51b to probe 53b, and port 52b communicates higher frequency signals to probe 19.

As may now be apparent, several selectable waveguides in combination with various frequency sensitive couplers and tapers can be coupled together and cascaded to provide a plurality of polarization states and frequency selections, all by means of simple rotation of the selectable waveguides. Hence, the selectable waveguide can be used for multiple frequency and multiple polarization selection and operation using both the straight and bent positions and using frequency selective tapers, coupler, and surfaces. These switches are cascaded so that the polarization selection can be made at desired frequencies. This

cascade arrangement permits independent polarization selection at each of the used frequencies.

The selectable waveguide switch can be readily applied a frequency selection application. However, other applications exist for the selectable waveguide. Waveguide switches are commonly used to connect other alternatives or redundant electronics into systems. For antennas designed to operate with several different satellites, the selectable switch can be used advantageously with different transmitters. As an example, a system may be required to provide both low and high data rate communications with different satellite systems. The transfer of high data rate information generally requires higher transmitted power than low data rate communications, and the frequency assignments within the band may differ somewhat between the satellite systems. The selectable waveguide switch can be used to connect two different transmitters having different power capabilities to the same antenna feed. Another common requirement is to be able to switch transmitters between the antenna and a dummy load. The dummy load permits operating the transmitters for diagnostic testing without radiating through the antenna causing needless interference. The selectable waveguide switch can be used advantageously in this application permitting use of a single dummy load for both orthogonal polarization states. Such a design can be more compact than one using two dummy loads for each polarization state. Those skilled in the art can make enhancements, improvements, and modifications to enhance the invention and extend the application of the

selectable waveguide switch. However, those enhancements, improvements and modifications may nonetheless fall within the spirit and scope of the following claims.

What is claimed is

1. A selectable waveguide having a first position and second position for communicating a signal between an input port and a first output port and a second output port, the selectable waveguide comprising,

a first waveguide section having a first waveguide shape for communicating the signal between the input port and the first output port when the selectable waveguide is in the first position, and

a second waveguide section having a second waveguide shape for communicating the signal between the input port and the second output port when the selectable waveguide is in the second position.

2. The selectable waveguide of claim 1 wherein

the input port is an antenna feed port,

the first waveguide shape is straight between the input port and the first output port, and

the second waveguide shape is bent defined by a reflecting surface for reflecting the signal between input port and the second port.

3. The selectable waveguide of claim 1 wherein,

the signal is communicated between an antenna feed coupled to the input port and a first probe coupled to the first output port through the first waveguide section when the signal is a first polarized signal, and

the signal is communicated between an antenna feed coupled to the input port and a second probe coupled to the second output port through the second waveguide section when the signal is a second polarized signal.

4. The selectable waveguide of claim 1 further comprising,

a rotating element for supporting the first and second waveguide sections, the rotating element can be rotated into the first and second positions,

a knob for manually rotating the rotating element between the first and second position, and

a stationary housing for supporting the rotating element.

5. A selectable waveguide having a first and second position for respectively communicating first or second signals from an antenna feed to respective first and second probes, the selectable waveguide comprising,

an antenna feed port coupled to the antenna feed for communicating the signals between the antenna feed and the first and second probes,

a first waveguide section having a first shape and coupled to the antenna feed port for communicating the first signal,

a first port coupled between the first probe and the first waveguide section for communicating the first signal between the first probe and the first waveguide section,

a second waveguide section having a second shape and coupled to the antenna feed port for communicating the second signal,

a second port coupled between the second probe and the second waveguide section for communicating the second signal between the second probe and the second waveguide section, and

an element for supporting the first and second waveguide sections, the element having a first position for communicating the first signal between the antenna feed port through the first waveguide section to the second port, the element having a second position for communicating the second signal between the antenna feed port through the second waveguide section to the second port.

6. The selectable waveguide of claim 5 wherein,

the element is a rotating element,

the first signal is a first polarized signal,

the first waveguide shape is straight,

the second signal is a second polarized signal,

the second waveguide shape is bent at ninety degrees having a forty-five degree reflective surface, and

the selectable waveguide is for selecting the communicating of either the first or second polarized signals, the first and second polarized signals are orthogonal to each other.

7. The selectable waveguide of claim 5 wherein,

the element is a rotating element,

the first signal is a circularly polarized signal,

the first waveguide shape is straight,

the second signal is a linearly polarized signal,

the second waveguide shape is bent at ninety degrees having a forty-five degree reflective surface, and

the selectable waveguide is for selecting the communication of either the circularly polarized signal or the linearly polarized signal.

8. The selectable waveguide of claim 5 wherein,

the second signal comprises a high frequency signal and a low frequency signal,

the reflective surface is a frequency selective reflective surface for reflecting low frequency signals to the second port and for passing high frequency signals to the first port,

the second waveguide section comprises a waveguide extension extending from the frequency selective reflective surface and the first port for communicating the high frequency signals to the first probe through the first port when the selectable waveguide is in the second position.

9. A selectable waveguide arrangement for respectively communicating first, second or third signals from an antenna feed to respective first, second and third probes, the selectable waveguide arrangement comprising a front end selectable waveguide and a back end selectable waveguide, wherein,

the front end selectable waveguide comprises:

an antenna feed port coupled to the antenna feed for communicating the first, second and third signals between the antenna feed and the first, second and third probes;

a first front end waveguide section having a first front end shape and coupled to the antenna feed port for communicating the second and third signals;

a first front end port coupled to back end selectable waveguide for communicating the second and third signals between the antenna feed port and the back end selectable waveguide;

a second front end waveguide section having a second front end shape and coupled to the antenna feed port for communicating the first signal;

a second front end port coupled between the first probe and the second front end waveguide section for communicating the first signal between the antenna feed port and the first probe through the second front end waveguide section; and

a front end element for supporting the first front end waveguide section and the second front end waveguide section, the front end element has a first front end position for communicating the second and third signals between the antenna feed port through the first front end waveguide section through the first front end port to the back end selectable waveguide, the front end element has a second front end position for communicating the first signal between the antenna feed port through the second front end waveguide section through the second front end port to the first probe, and wherein,

the back end selectable waveguide comprises:

a back end input port coupled to the first front end port for communicating the second and third signals between the first front end port respectively to the second and third probes;

a first back end waveguide section having a first back end shape and coupled to the back end input port for communicating the second and third signals;

a first back end port coupled to the first back end waveguide section for communicating the third signal between the back end input port and the third probe through the first back end waveguide section;

a second back end waveguide section having a second back end shape and coupled to the back end input port for communicating the second signal;

a second back end port coupled between the second back end waveguide section and the second probe for communicating the second signal between the back end input port and the second probe through the second back end waveguide section; and

a back end element for supporting the first back end waveguide section and the second back end waveguide section, the back end element has a first back end position for communicating the third signal between the back end input port through the first back end waveguide section through the first back end port to the third probe, the back end element has a second back end position for communicating the second signal between the back end input port through the second back end waveguide section through the second back end port to the second probe.

10. The selectable waveguide arrangement of claim 9 wherein,

the first front end waveguide section shape is straight and uniform in cross section between the antenna feed port and the first front end port,

the first back end waveguide section shape is straight and uniform in cross section between the back end input port and the first back end port,

the second front end waveguide section shape is bent at ninety degrees having a forty-five degree reflective surface and uniform in cross section between the antenna feed port and the second front end port, and

the second back end waveguide section shape is bent at ninety degrees having a forty-five degree reflective surface and uniform in cross section between the back end input port and the second back end port.

11. The selectable waveguide arrangement and claim 9 wherein,

the first and second front end waveguide sections have a smaller cross section than the first and second back end waveguide sections.

12. The selectable waveguide arrangement of claim 9 wherein the second and third signals are polarized signals and are orthogonally polarized respecting each other.

13. The selectable waveguide arrangement of claim 9, wherein the first front end port is a tapered port for attenuating low frequency components of the second and third signals.

14. The selectable waveguide arrangement of claim 9, wherein the third signal comprises a fourth signal and a fifth signal, the selectable waveguide arrangement is coupled to a fourth probe and a fifth probe, selectable waveguide arrangement further comprises,

a coupler coupled to the first front end port and comprising a fourth port and fifth port respectively coupled to the fourth and fifth probes, the fourth and fifth signals are orthogonally polarized and the fourth and fifth probes are polarization sensitive to respectively communicate the fourth and fifth signals between the antenna feed port and the fourth and fifth probes through the first front end waveguide section and fourth and fifth ports.

Abstract of the Disclosure

A selectable waveguide transitions between two positions to at least two independent signals by their polarization or frequency. This waveguide consists of dissimilar wave sections coupled to an antenna feed and is mechanically actuated for signal selection switching to route signals to output ports and respective probes that are polarization sensitive. The waveguide sections offer high polarization purity so that signal components remain separated to avoid mutual interference and low insertion loss to maintain system efficiency. Selectable waveguide can be extended for multiple polarization and frequency operation. Frequency selective surfaces and tapers establish pass bands and attenuation levels for frequency selection. The selectable waveguide is suitable for both frequency and polarization selectively in antenna system. Selectable waveguides can be cascaded and mechanically actuated for creating selectable waveguides arrangements enabling a wide variety of frequency and polarization selectively operating through a single apparatus.

PATENT

Attorney's Docket No. D-350

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type:

/X/ original

INVENTORSHIP IDENTIFICATION

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

ORTHOGONAL POLARIZATION AND FREQUENCY SELECTABLE WAVEGUIDE

SPECIFICATION IDENTIFICATION

The specification of which is attached hereto.

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations section 1.56(a).

/X/ In compliance with this duty there is attached an information disclosure statement. 37 CFR 1.97.

(Rel.33-4/87 Pub.605) FORM 1-1

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) and/or agents(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Derrick Michael Reid, Reg. No. 32,096

SEND CORRESPONDENCE TO:

Derrick M. Reid
Patent Attorney
The Aerospace Corporation
P. O. Box 92957 (M1/040)
Los Angeles, CA 90009-2957

DIRECT TELEPHONE CALLS TO:

Derrick M. Reid
(310) 336-6708

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued theron.

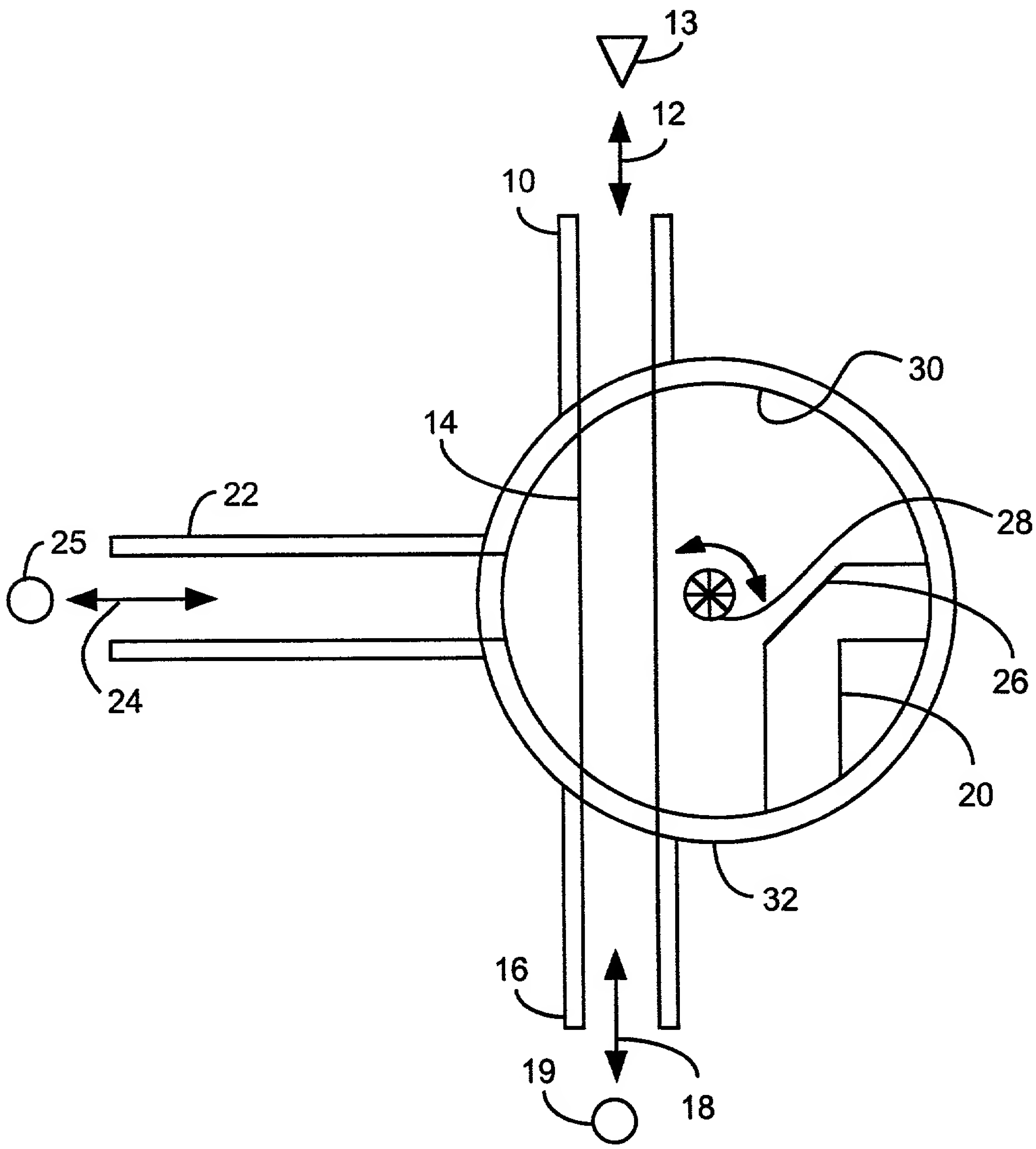
SIGNATURE(S)

Full name of sole or first inventor: Robert B. Dybdal
Inventor's signature: Robert B Dybdal
Date: December 16, 1998 Country of Citizenship: U.S.A.
Residence: 2549 Palos Verdes Dr. West, Palos Verdes Estates, CA 90274
Post Office Address: 2549 Palos Verdes Dr. West, Palos Verdes Estates, CA 90274

Full name of second joint inventor, if any, ____
Inventor's signature: ____
Date: ____ Country of Citizenship: U.S.A.
Residence: ____
Post Office Address: ____

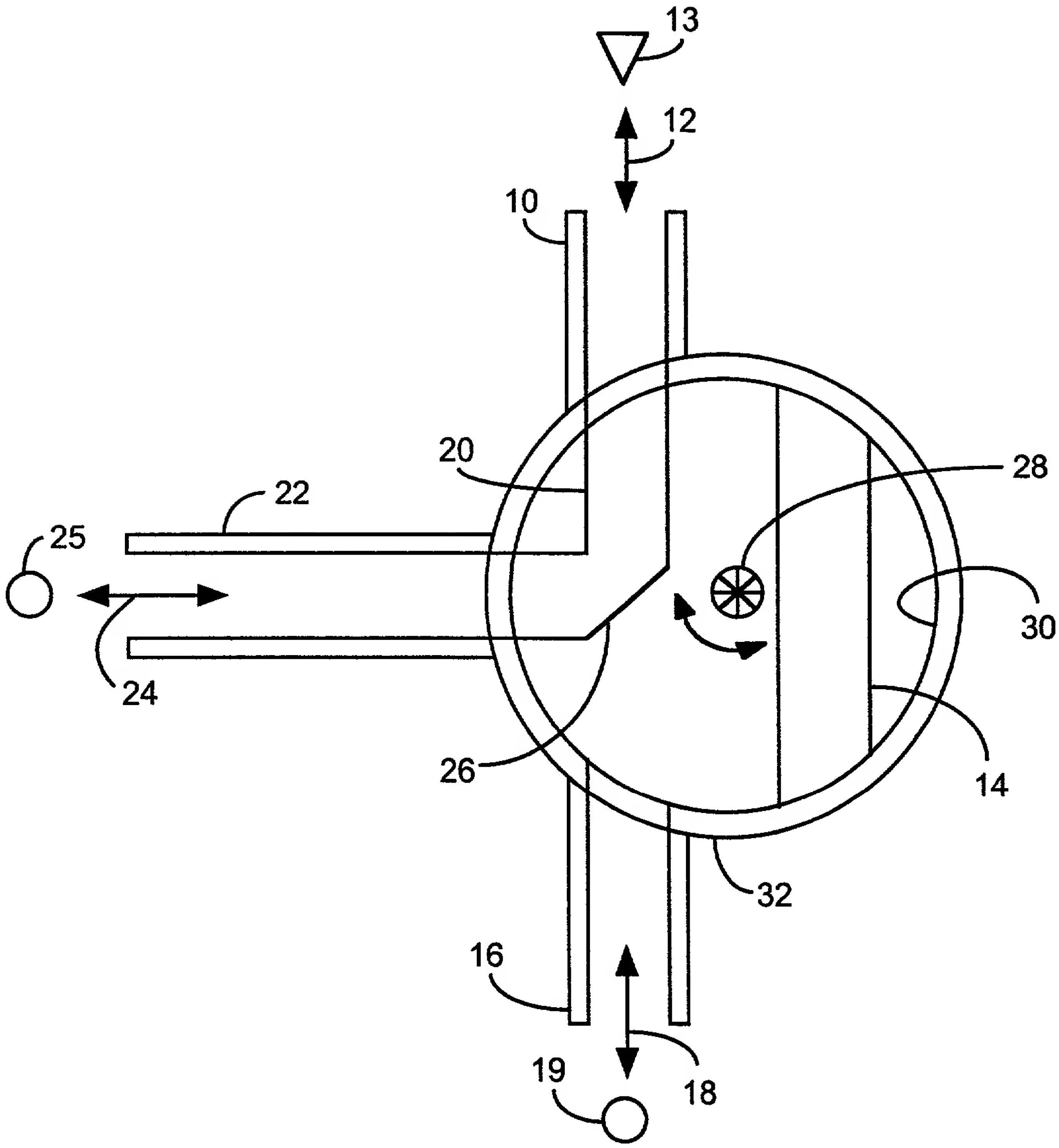
Full name of third joint inventor, if any: ____
Inventor's signature: ____
Date: ____ Country of Citizenship: ____
Residence: ____
Post Office Address: ____

X This Declaration ends with this page-- page 2 of 2)



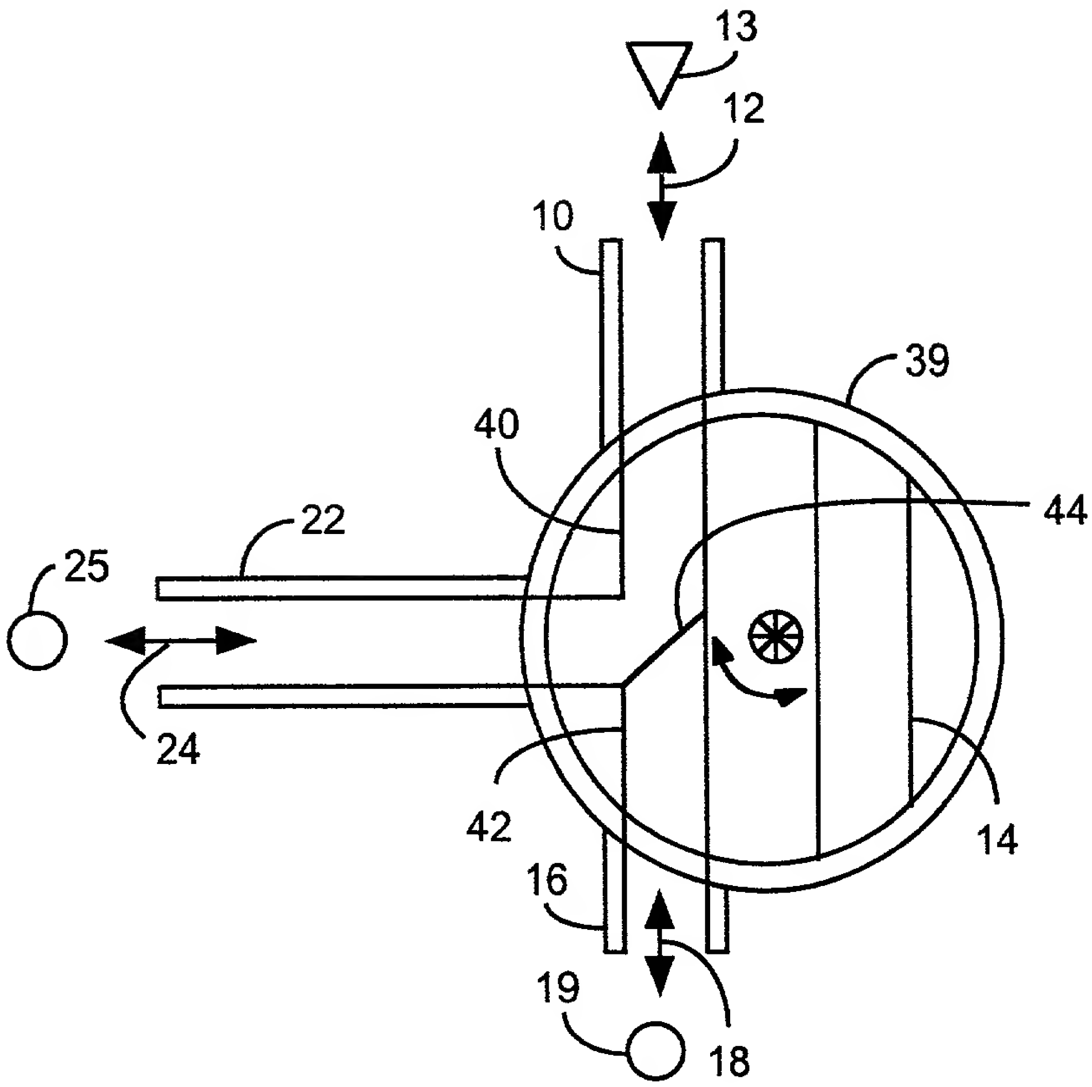
STRAIGHT POSITIONED SELECTABLE WAVEGUIDE

FIG. 1



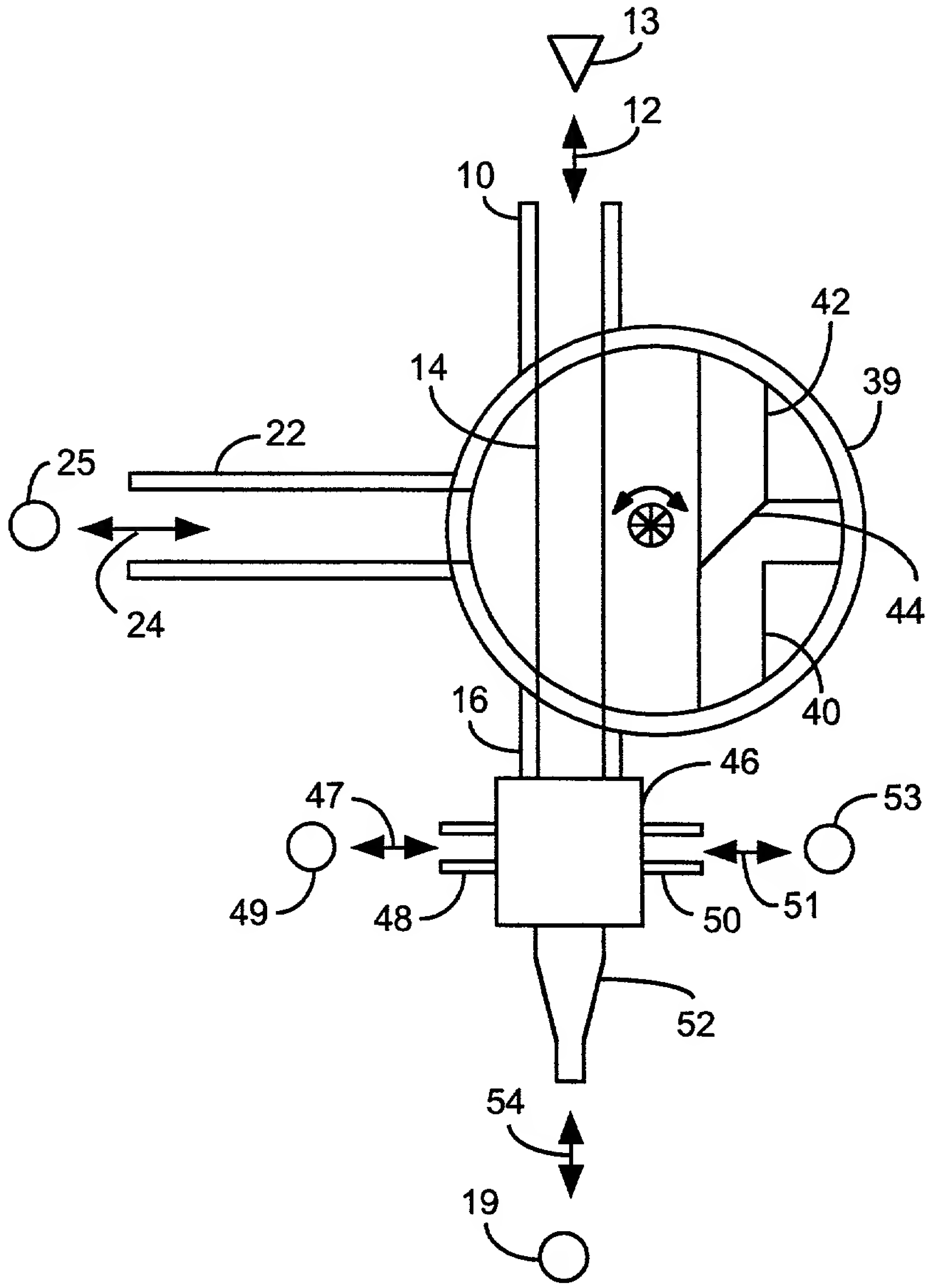
BENT POSITIONED SELECTABLE WAVEGUIDE

FIG. 2



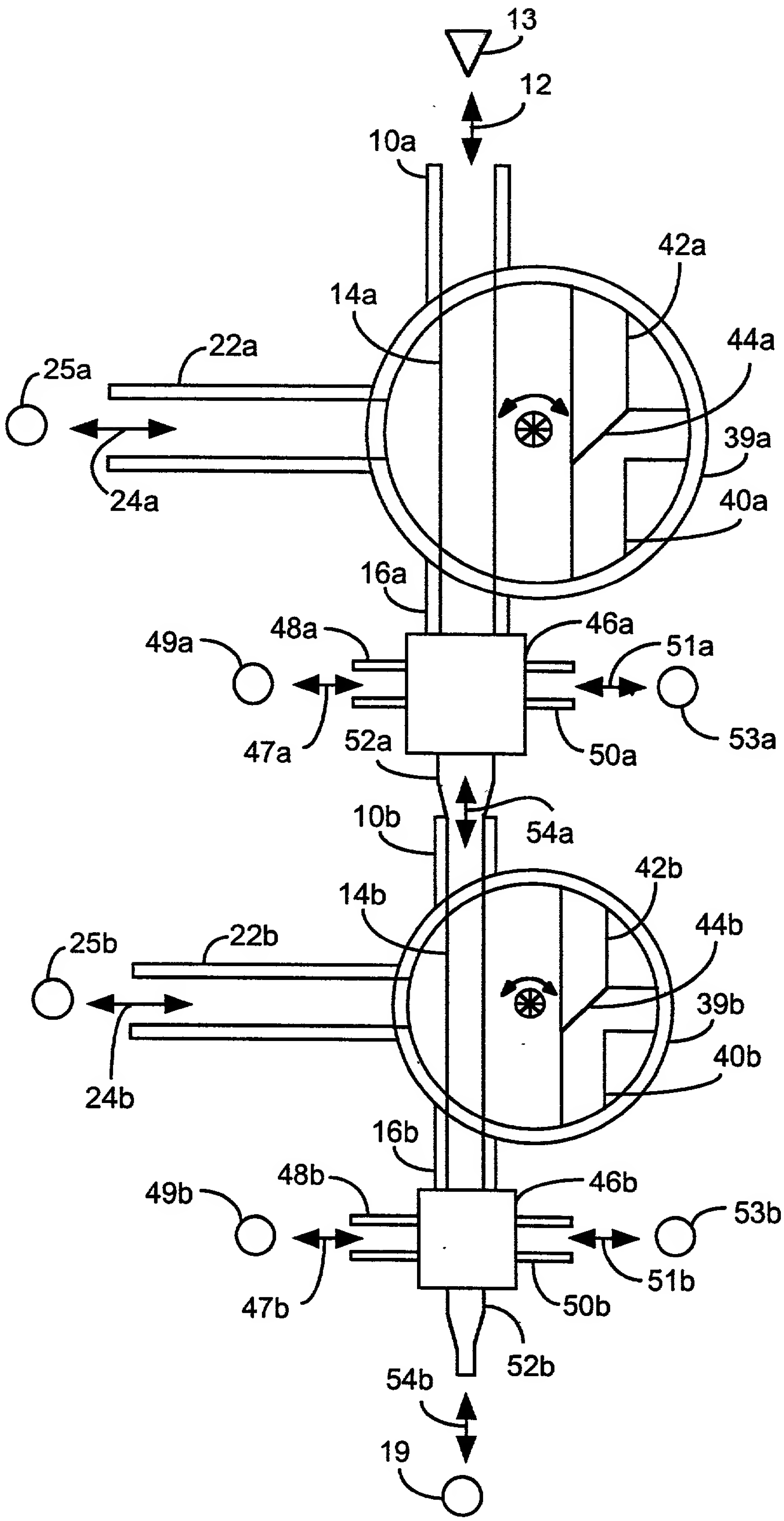
MODIFIED BENT POSITIONED WAVEGUIDE

FIG. 3A



STRAIGHT POSITIONED WAVEGUIDE

FIG. 3B



CASCADED SELECTABLE WAVEGUIDES

FIG. 4

PATENT

Attorney's Docket No. D-350

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Inventor's signature: ________

Date: ________ Country of Citizenship: U.S.A.

Residence: ________

Post Office Address: ________

Full name of third joint inventor, if any: ________

Inventor's signature: ________

Date: ________ Country of Citizenship: ________

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PATENT

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